Topic B – Human Biochemistry B1-6 SL B1-9 HL

IB Chemistry

Topic B – Biochem

B1 Energy - 0.5 hour

- B.1.1 Calculate the energy value of a food from enthalpy of combustion data. (2)

B2 Proteins - 3 hours

- B.2.1 Draw the general formula of 2-amino acids. (1)
- B.2.2 Describe the characteristic properties of 2-amino acids (2)
- B.2.3 Describe the condensation reaction of 2-amino acids to form polypeptides. (2)
- B.2.4 Describe and explain the primary, secondary ('-helix and (-pleated sheets), tertiary and quaternarystructure of proteins. (3)
- B.2.5 Explain how proteins can be analysed by chromatography and electrophoresis. (3)
- B.2.6 List the major functions of proteins in the body. (1)

B3 Carbohydrates - 3 hours

- B.3.1 Describe the structural features of monosaccharides. (2)
- B.3.2 Draw the straight-chain and ring structural formulas of glucose and fructose. (1).
- B.3.3 Describe the condensation of monosaccharides to form disaccharides and polysaccharides. (2)
- B.3.4 List the major functions of carbohydrates in the human body. (1)
- B.3.5 Compare the structural properties of starch and cellulose, and explain why humans can digest starch but not cellulose. (3)
- B.3.6 State what is meant by the term dietary fibre. (1)
- B.3.7 Describe the importance of a diet high in dietary fibre. (2)

B4 Lipids - 3.5 hours

- B.4.1 Compare the composition of the three types of lipids found in the human body. (3)
- B.4.2 Outline the difference between HDL and LDL cholesterol and outline its importance. (2)
- B.4.3 Describe the difference in structure between saturated and unsaturated fatty acids. (2)
- B.4.4 Compare the structures of the two essential fatty acids linoleic (omega–6 fatty acid) and linolenic (omega–3 fatty acid) and state their importance. (3)
- B.4.5 Define the term iodine number and calculate the number of C=C double bonds in an unsaturated fat/oil using addition reactions. (2)
- B.4.6 Describe the condensation of glycerol and three fatty acid molecules to make a triglyceride. (2)
- B.4.7 Describe the enzyme-catalysed hydrolysis of triglycerides during digestion. (2)
- B.4.8 Explain the higher energy value of fats as compared to carbohydrates. (3)
- B.4.9 Describe the important roles of lipids in the body and the negative effects that they can have on health. (2)

B5 Micronutrients and macronutrients - 2 hours

- B.5.1 Outline the difference between micronutrients and macronutrients. (2)
- B.5.2 Compare the structures of retinol (vitamin A), calciferol (vitamin D) and ascorbic acid (vitamin C). (3)
- B.5.3 Deduce whether a vitamin is water- or fat-soluble from its structure. (3)
- B.5.4 Discuss the causes and effects of nutrient deficiencies in different countries and suggest solutions. (3)

B6 Hormones - 3 hours

- B.6.1 Outline the production and function of hormones in the body. (2)
- B.6.2 Compare the structures of cholesterol and the sex hormones. (3)
- B.6.3 Describe the mode of action of oral contraceptives. (2)
- B.6.4 Outline the use and abuse of steroids. (2)

HL Material

Topics 7-9 are for HL students only

(HL) B7 Enzymes - 3 hours

- B.7.1 Describe the characteristics of biological catalysts (enzymes). (2)
- B.7.2 Compare inorganic catalysts and biological catalysts (enzymes). (3)
- B.7.3 Describe the relationship between substrate concentration and enzyme activity. (2)
- B.7.4 Determine Vmax and the value of the Michaelis constant (Km) by graphical means and explain its significance. (3)
- B.7.5 Describe the mechanism of enzyme action, including enzyme substrate complex, active site and induced fit model. (2)
- B.7.6 Compare competitive inhibition and non-competitive inhibition. (3)
- B.7.7 State and explain the effects of heavymetal ions, temperature changes and pH changes on enzyme activity. (3)

(HL) B8 Nucleic acids - 3 hours

- B.8.1 Describe the structure of nucleotides and their condensation polymers (nucleic acids or polynucleotides). (2)
- B.8.2 Distinguish between the structures of DNA and RNA. (2) RNA has ribose as its pentose sugar; DNA has deoxyribose. Deoxyribose lacks an oxygen atom on C2. RNA has uracil instead of thymine as its base. RNA is a single-strand nucleic acid; DNA is a doublestrand nucleic acid.
- B.8.3 Explain the double helical structure of DNA. (3)
- B.8.4 Describe the role of DNA as the repository of genetic information, and explain its role in protein synthesis. (2)
- B.8.5 Outline the steps involved in DNA profiling and state its use. (2)

B9 Respiration - 1 hour

- B.9.1 Compare aerobic and anaerobic respiration of glucose in terms of oxidation/reduction and energy released. (3)
- *B.9.2 Outline the role of copper ions in electron transport and iron ions in oxygen transport. (2)*

Topic B1 - Energy

- B.1.1 Calculate the energy value of a food from enthalpy of combustion data. (2)

B1.1 - Living Organisms

Introduction

- Living organisms have to be able to:
  - Exchange matter and energy with their surroundings.
  - Transform matter and energy into different forms.
  - Respond to changes in their environment.
  - Grow.
  - Reproduce.

B1.1 - Macromolecules

- All of these changes are due to large organic compounds called **macromolecules**.
  - A macromolecule is a combination of many smaller similar molecules polymerized into a chain structure.
- In living organisms there are three main types of macromolecules which control all activities and determine what an organism will do and become.
  - Proteins.
  - Carbohydrates
  - Nucleic acids.

B1.1 - Cells

- The basic unit of life is the **cell.**
  - The cell makes up all living organisms that we know of.
  - Cells are in turn made of macromolecules that form inside the cell.
  - Other macromolecules control the formation of these macromolecules.
- **Metabolism** is the breaking down or building up of macromolecules.
  - Generally, breaking down macromolecules releases energy that the organism can use as an energy source.
  - The building up of macromolecules requires energy, that is obtained from breaking down macromolecules.

B1.1 - Respiration

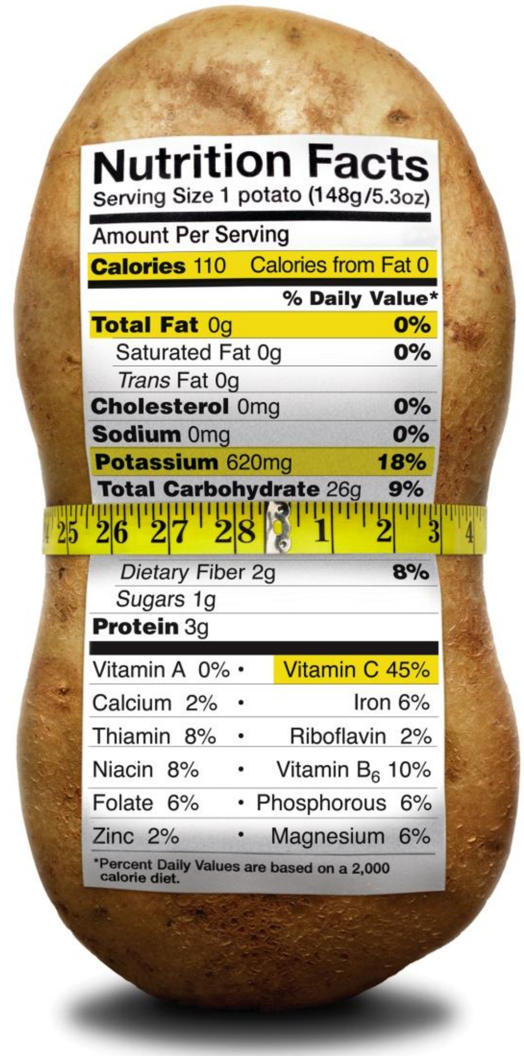
- Energy is made available in the body through a series of reactions known as **respiration**.
  - Usually begins with the simple sugar molecule glucose.
  - Other energy-rich molecules are usually first converted into glucose or intermediates by metabolic processes.
- The body is therefore dependent on a continuous supply of energy-rich molecules to drive the reactions of metabolism.
  - The source of these molecules is our diet, so knowing the energy content of different food types is of great importance.

B1.1 – Respiration 2

- It is estimated that moderately active men and women require the following energy consumption per day
  - Women = 9200 kJ
  - Men = 12600 kJ
- If we intake a greater quantity of energy-rich molecules than needed, most is converted into storage molecules such as fat for later use.
- The concept of 'dieting' effectively reverses this process by ensuring that we take in less energy-rich food than the body needs, so that these stored molecules are used up to provide the energy

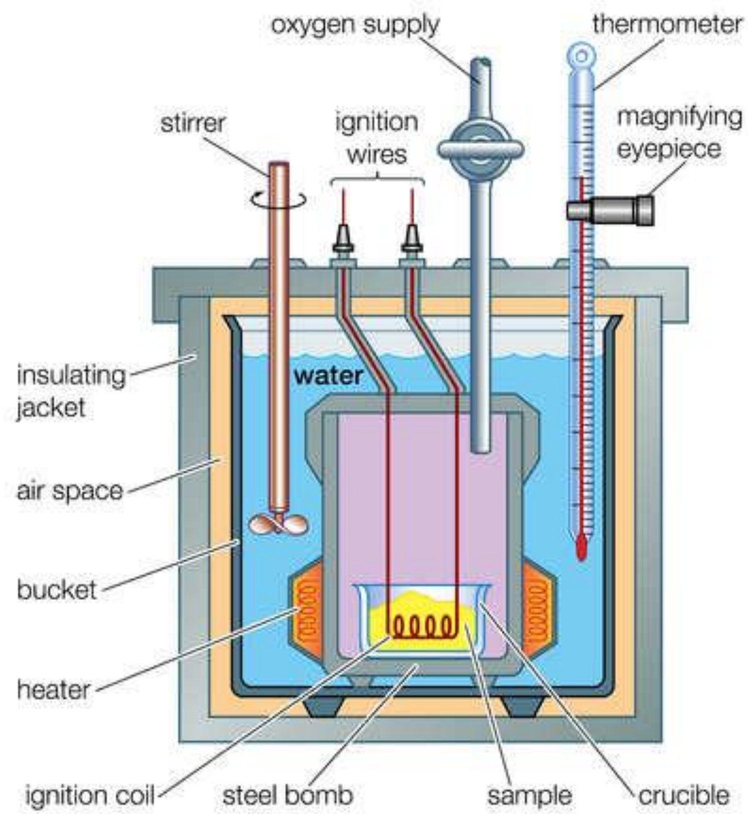
B1.1 – Food Energy

- Many foods display their energy values on packaging (in the states it's required). This food undergoes an enzyme-controlled combustion known as respiration
- Although we can't measure the energy directly, we can measure the enthalpy changes for dried samples of the food with use of a bomb calorimeter.



B1.1 - Calorimetry

- Food is burned to completion after being ignited electrically (the bomb) and the heat released as it burns is measured by recording the temperature rise in a known mass of pure water.
- We use the equation
  - $q = mc\Delta T$
  - Energy lost = energy gained
    - $q_{food} = -(q_{H2O})$



Bomb Calorimeter

B1.1 - Equations for Heat Change (q)

The ***specific heat*** (*c*) of a substance is the amount of **heat** **(*q*)** required to raise the temperature of **one gram** of the substance by **one degree** Celsius.

Usually use specific heat, but you can use the ***heat capacity*** (*C*) as well [c substance is the amount of **heat (*q*)** required to raise the temperature of a given quantity in **mass (*m*)** of the substance by **one degree** Celsius.]

$$C = mc$$

Table 6.1 **The Specific Heats of Some Common Substances**

Substance	Specific heat (J/g · °C)
Al	0.900
Au	0.129
C (graphite)	0.720
C (diamond)	0.502
Cu	0.385
Fe	0.444
Hg	0.139
H_2O	4.184
C_2H_5OH (ethanol)	2.46

Heat (*q*) absorbed or released:

$$q = mc\Delta t$$

$$q = C\Delta t$$

$$\Delta t = t_{final} - t_{initial}$$

B1.1 - Variables for Heat Change:

- **q**, is the **heat change** within the system
- **c**, is the **specific heat** of the substance
  - Does not take into account the mass
  - Use the equation $q = ms\,\Delta T$
- **C**, is the **heat capacity** of the substance
  - Takes into account the mass
  - Use the equation $q = C\,\Delta T$
- **m**, is the **mass** of the substance
- **ΔT**, is the **change in temperature**
  - $\Delta T = T_f - T_i$

B1.1 – Calorimetry Review

- A 0.78 g sample of a food substance was combusted in a bomb calorimeter and raised the temperature of 105.10 g of water from 15.4^{o}C to 30.6^{o}C. Calculate the energy value of the food in kJ/g.
  - m_{H2O} = 105.10 g
  - ΔT = Tf-Ti = 30.6-15.4 = 15.2^{o}C or 15.2 K
  - c_{H2O} = 4.184 J/g^{o}C
  - q = mcΔT = (105.10 g)(4.184 J/g^{o}C)(15.2^{o}C)
  - q = 6677.63 J per 0.78 g sample heated
  - Energy value = 6677.63 J / 0.78 g
    - Energy = 8561.1 J/g OR 8.56 kJ/g

B1.1 - Calorimetry

- You may be asked to express your answer in J/mol instead of J/g
  - A simple conversion with molar mass will get you there
  - Ex. 1.50 g of glucose, $C_6H_{12}O_6$, was completely combusted in a bomb calorimeter. The heat evolved raised the temperature of 225.00 g of water from 18.50^oC to 27.96^oC. Calculate the energy value of glucose in kJ/mol.